Ambisonics plug-in suite for production and performance usage

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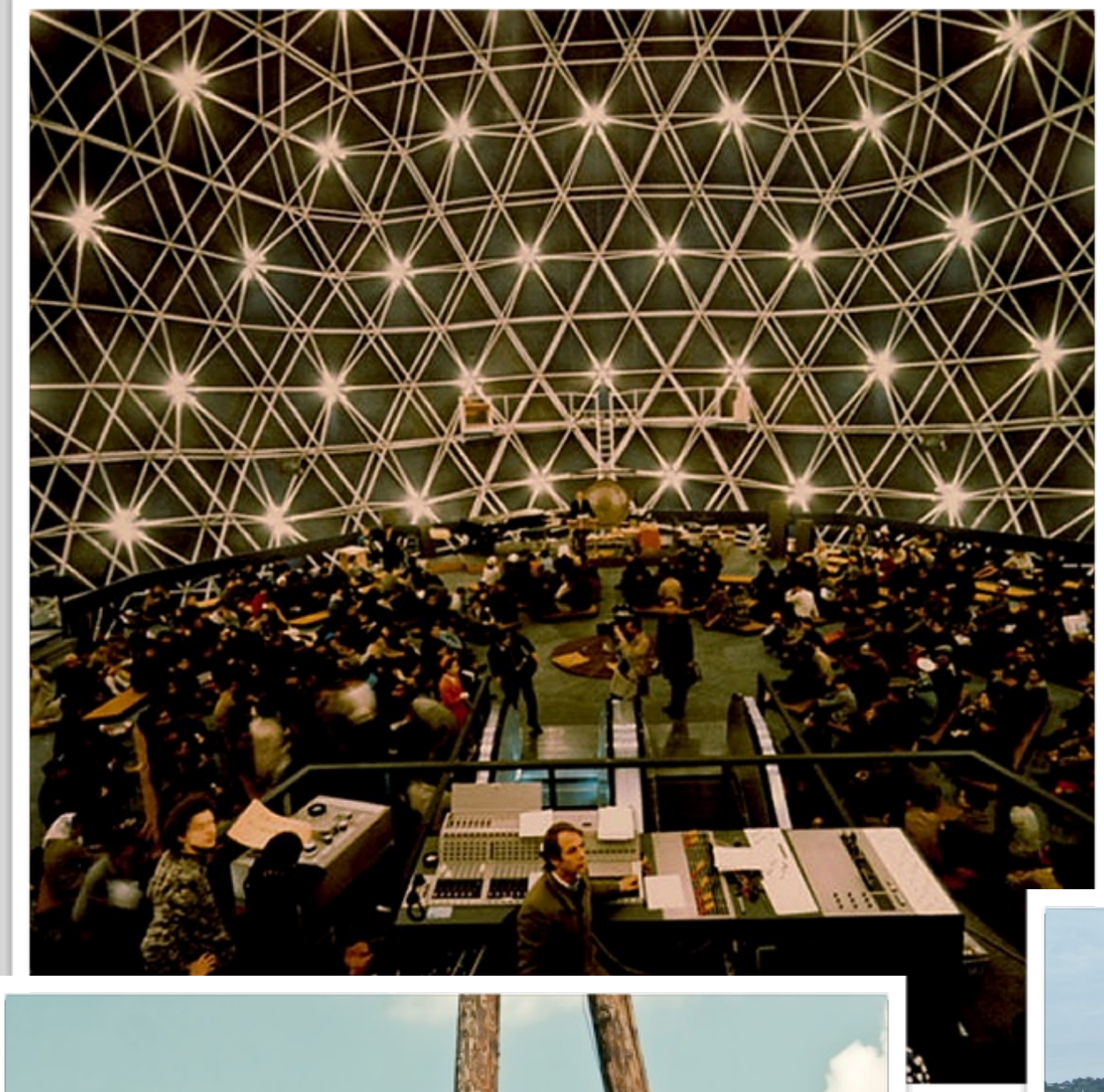
Linux Audio Conference 2013
May 9th - 12th, 2013
Graz, Austria

What?

- used JUCE framework to create cross-platform audio plug-ins (LV2, VST, AU) and Jack standalone apps
- above 3rd order Ambisonics, ambix convention
- advanced (remote) control features for the encoder
- binaural decoder with customizable presets



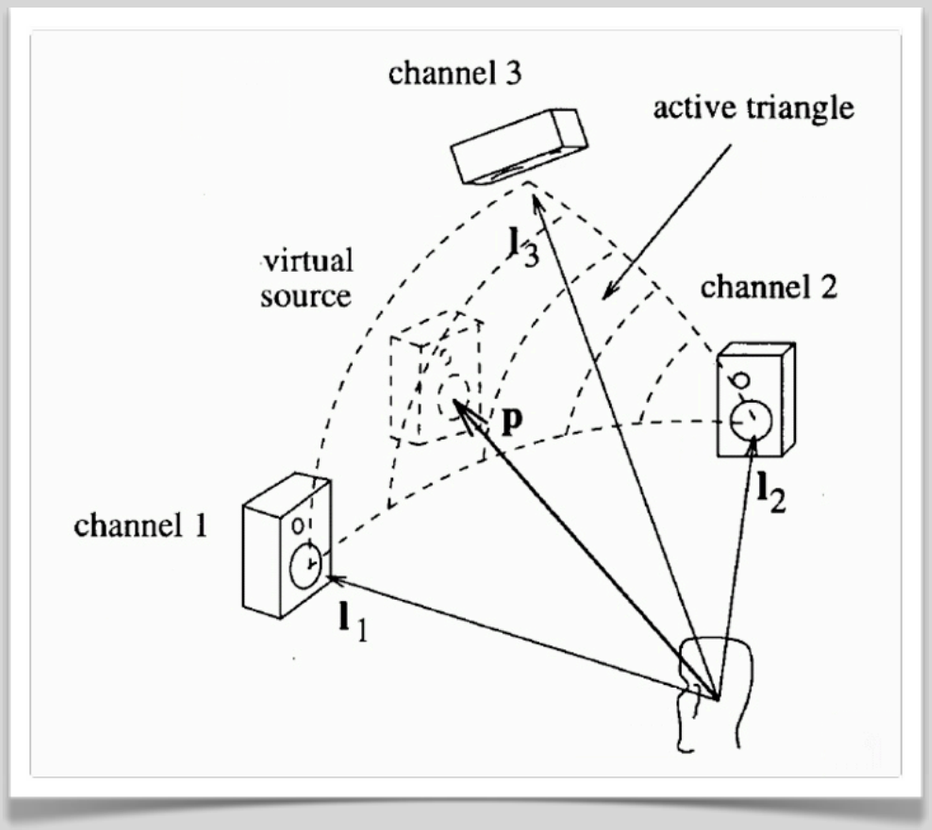
Pischelsdorf (AT), 2011-??

What is Ambisonic(s)?

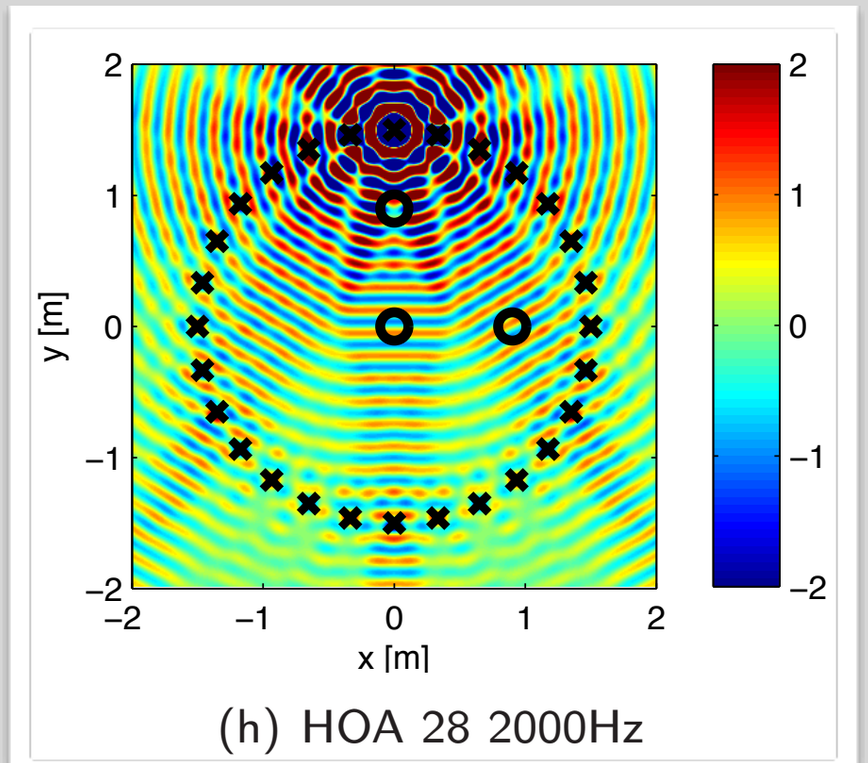
- surround recording and playback technique, Michael Gerzon 1970s
- little commercial success so far, patents expired
- independent of playback loudspeaker configuration, scaleable
- 2D and 3D sound-fields can be synthesized

What is Ambisonic(s)?

- not using phantom sources (VBAP, DBAP)
- trying to recreate original sound-field in sweet spot



Vector Based Amplitude Panning (V.Pulkki)



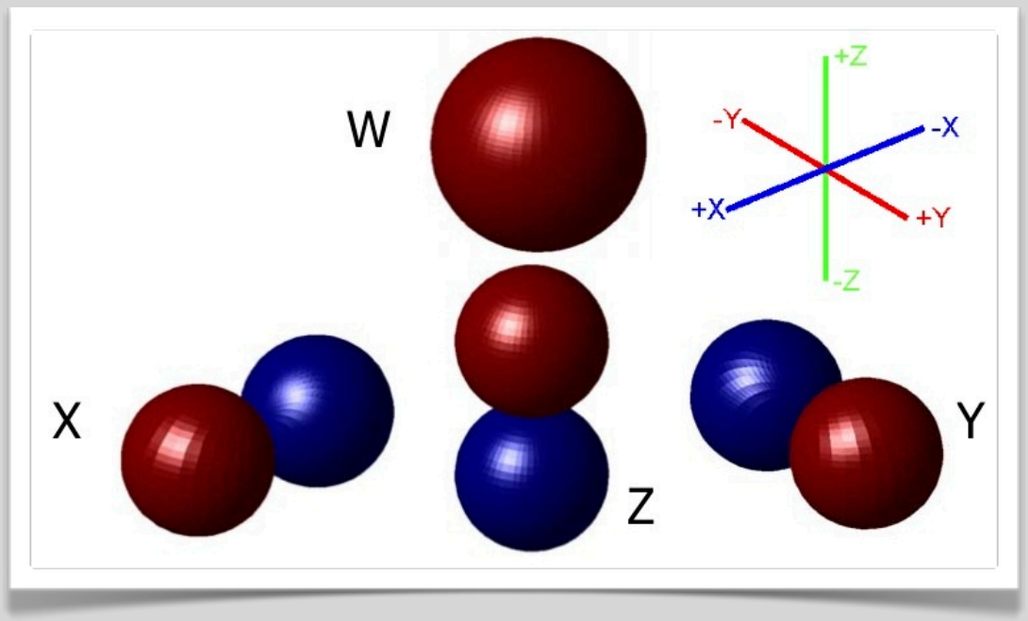
plane wave from 0° (M. Frank)

What is Ambisonic(s)?

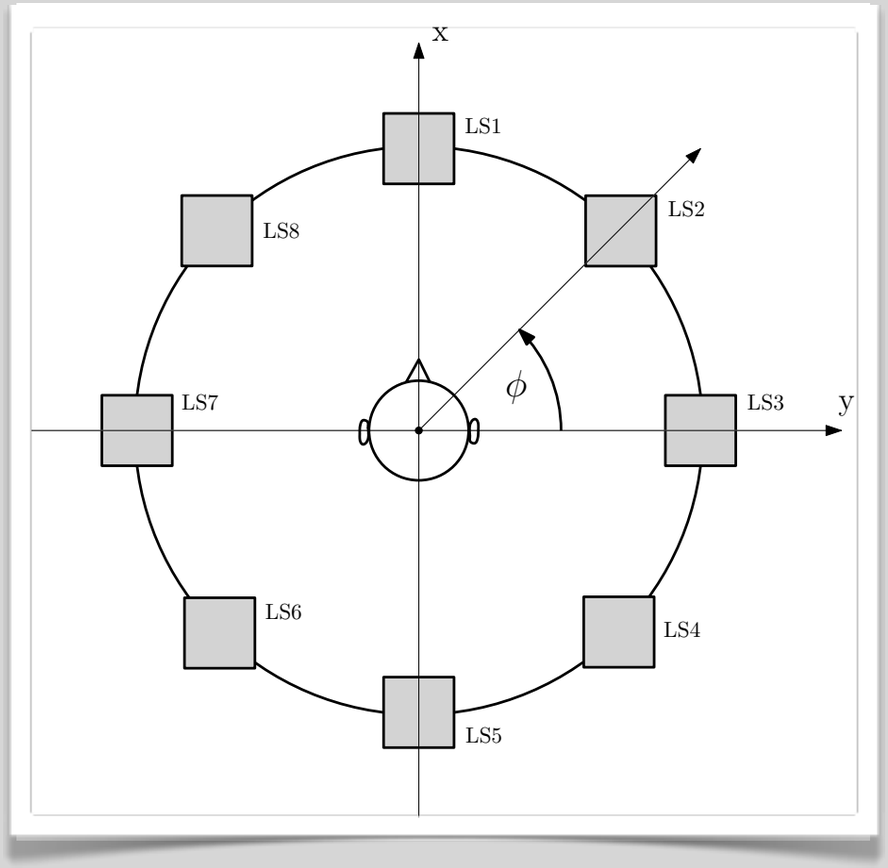
- loudspeaker feeds are a linear combination of the B-format signals (decoder matrix) e.g.:

$$p_j = \frac{1}{L}\left[W \cdot (\frac{1}{\sqrt{2}}) + X \cdot (\cos\phi_j \cos\theta_j) + Y \cdot (\sin\phi_j \cos\theta_j) + Z \cdot (\sin\theta_j)\right]$$

- ALL speakers work together to synthesize the sound-field



B-Format (1st order Ambisonics)

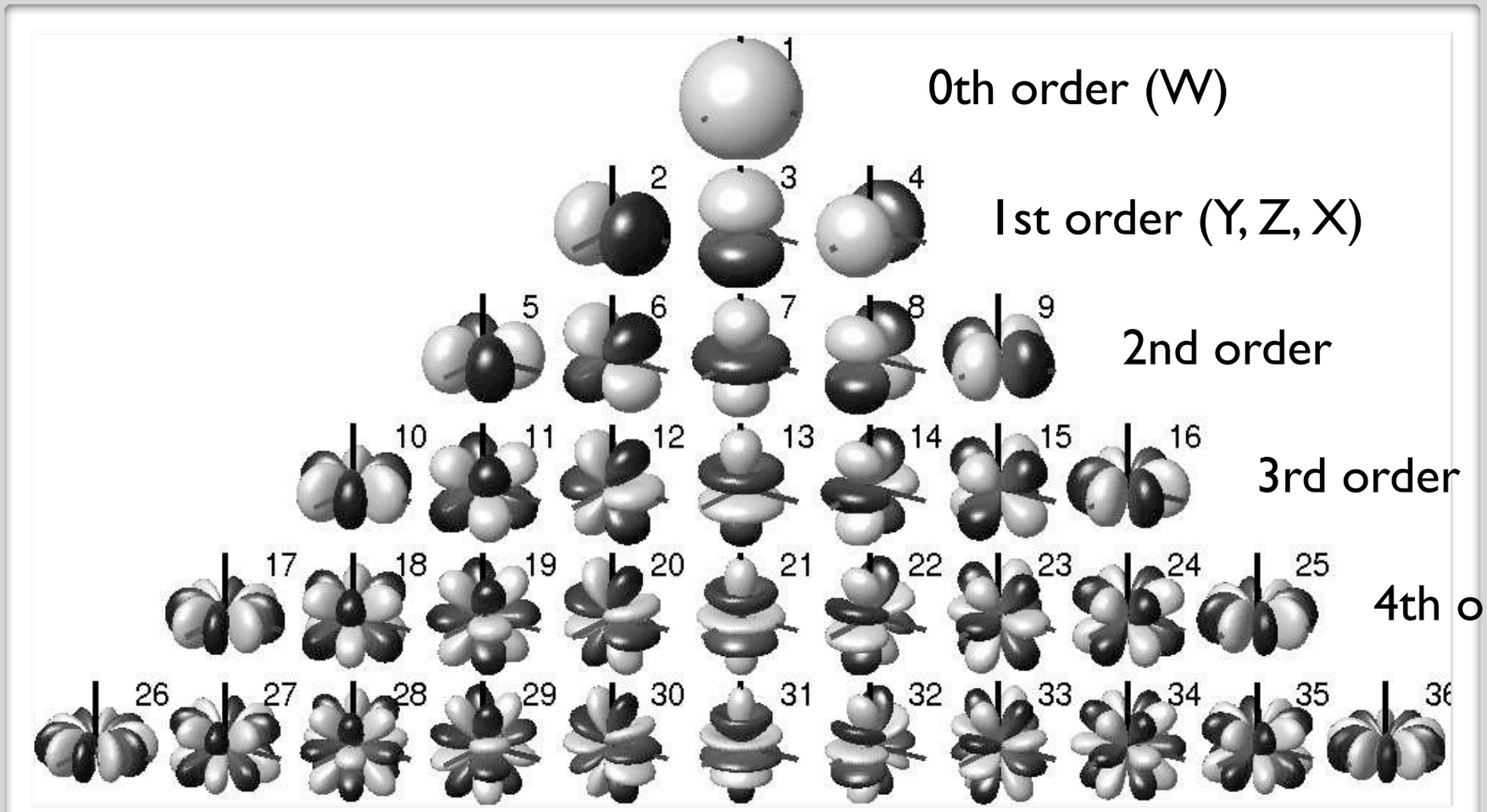


Regular 2D loudspeaker placement

What is Ambisonic(s)?

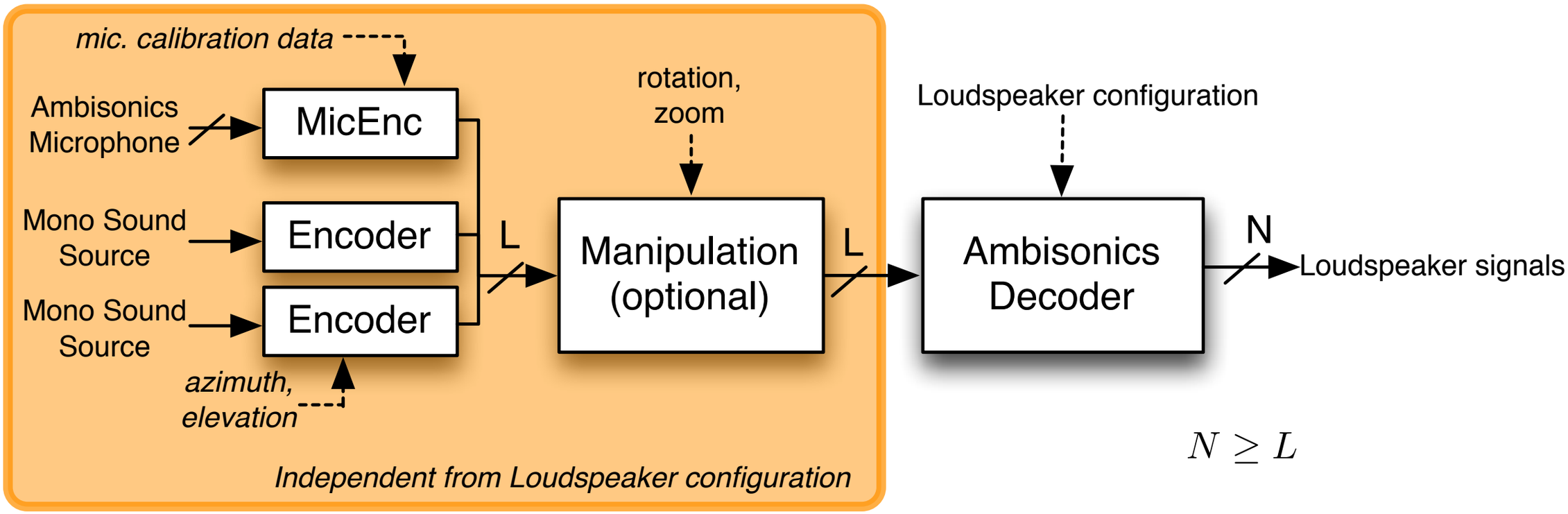
sound field is “sampled” using spherical harmonics:

2D: 2N+1 or 3D: (N+1)^2



Spherical harmonics up to 5th order 3D

Ambisonics production chain



$$N \geq L$$

$$L_{3D} = (M+1)^2$$

$$L_{2D} = 2M + 1$$

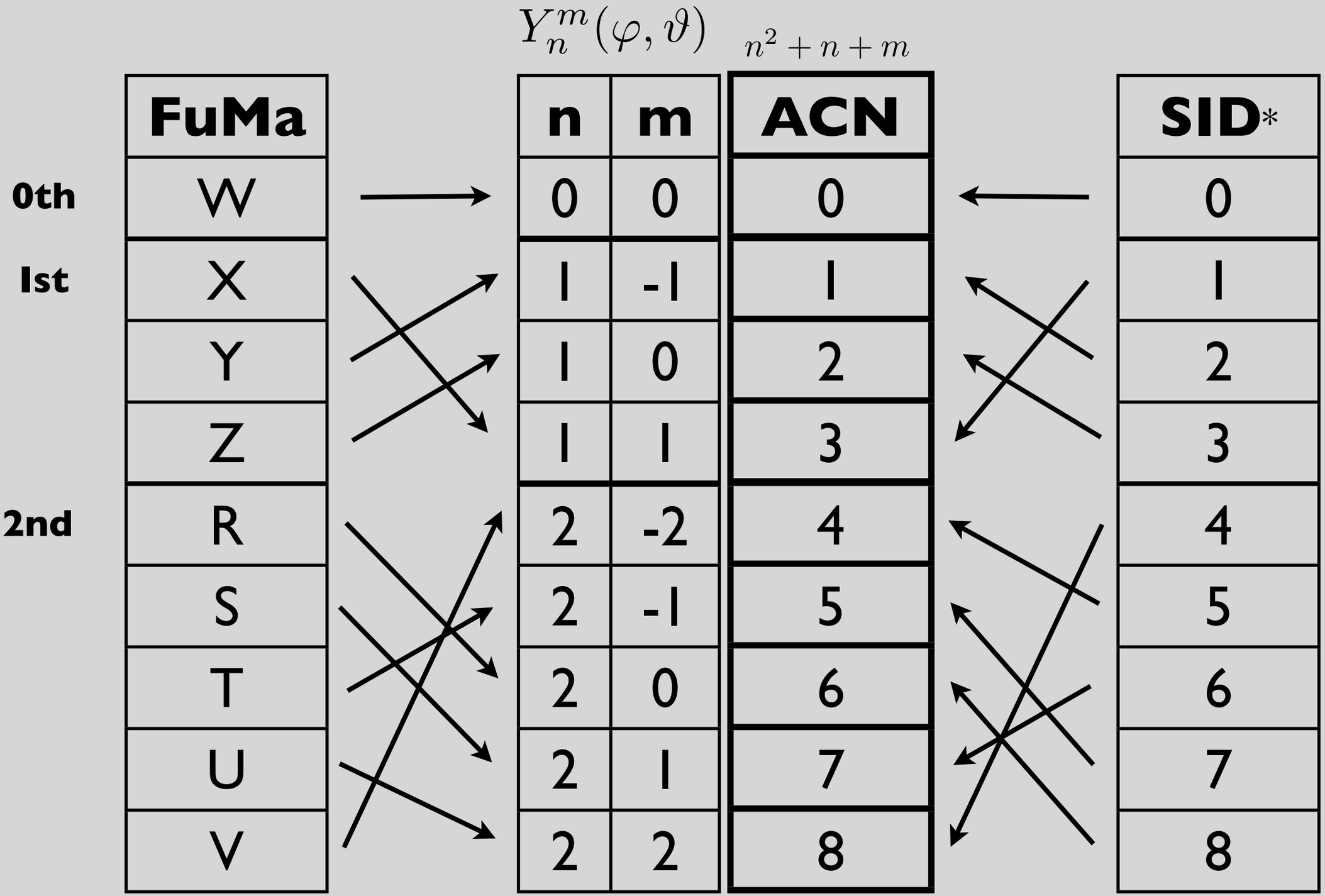
M… Ambisonics Order
L… Number of Ambisonics Channels
N… Number of Loudspeakers

overview of an Ambisonics production/playback system

Problems with existing solutions

- DAWs handling high channel count - Ardour and Reaper
- operating system compatibility (Win, Mac OS, Linux) and plug-in standards (VST, AU, AAX, RTAS, LV2, LADSPA)
- listening/producing at “home”?
- jumps in angular representation between -180° and 180°
- keeping track of the sound source positions
- different standards about channel sequence and normalization, restricted orders

Channel sequence



* Single Index Designation

Channel sequence

$Y_n^m(\varphi, \vartheta)$ $n^2 + n + m$

	FuMa	n	m	ACN	SID
0th	W	0	0	0	0
1st	Y	1	-1	1	2
	Z	1	0	2	3
	X	1	1	3	1
2nd	V	2	-2	4	5
	T	2	-1	5	7
	R	2	0	6	8
	S	2	1	7	6
	U	2	2	8	4
3rd	...	...			

Channel normalization

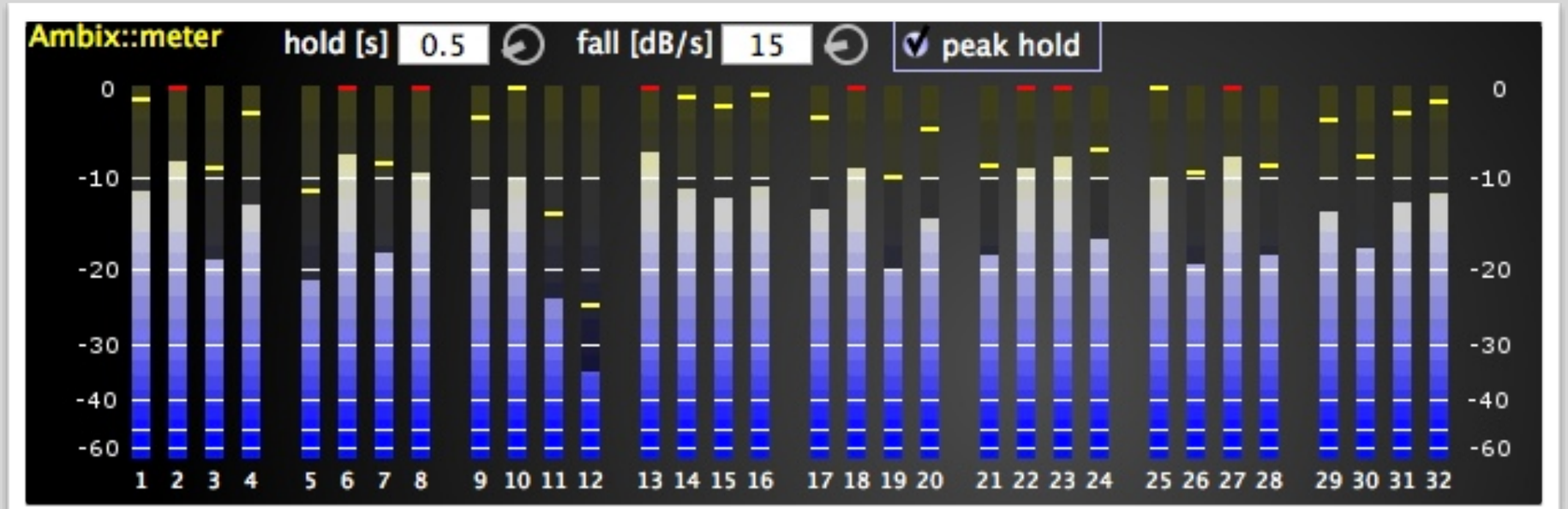
$Y_n^m(\varphi, \vartheta)$

	N3D
0th	0dB
1st	4.77dB
	4.77dB
	4.77dB
2nd	6.99dB
	6.99dB
	6.99dB
	6.99dB
	6.99dB
3rd	...

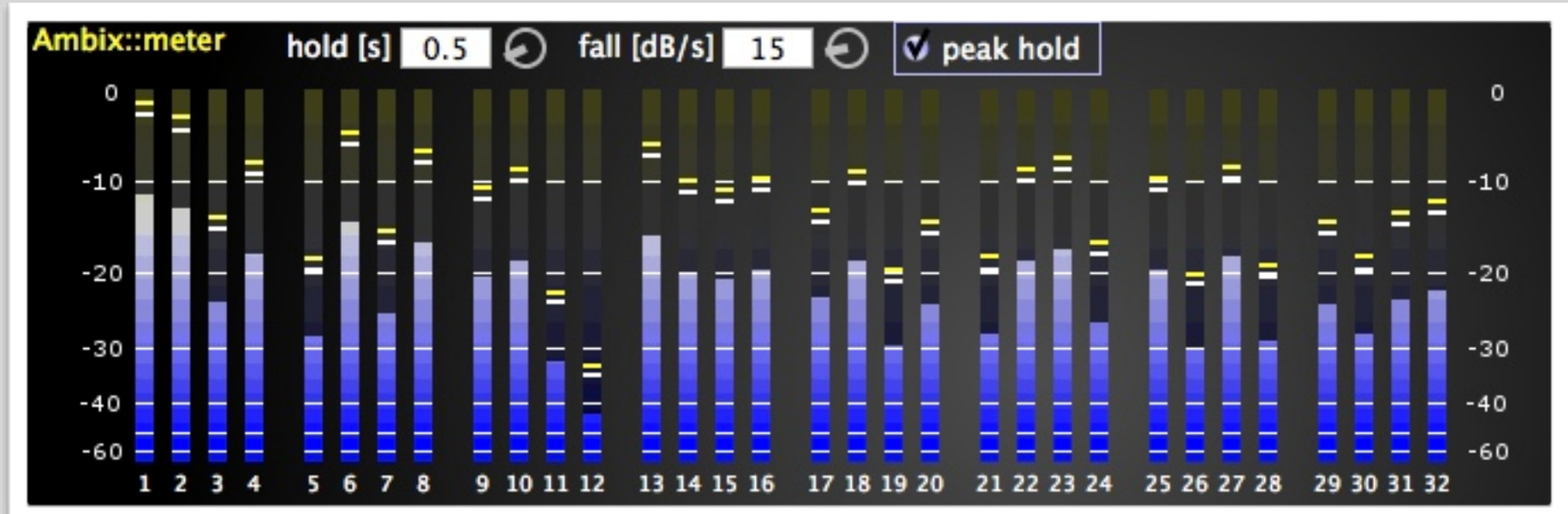
n	m	SN3D
0	0	0dB
1	-1	0dB
1	0	0dB
1	1	0dB
2	-2	0dB
2	-1	0dB
2	0	0dB
2	1	0dB
2	2	0dB

FuMa
-3dB
0dB
0dB
0dB
1.25dB
1.25dB
0dB
1.25dB
1.25dB
converter example...!

Channel normalization



N3D: clipping of higher order components



SN3D: no channel exceeds 0th order (W)

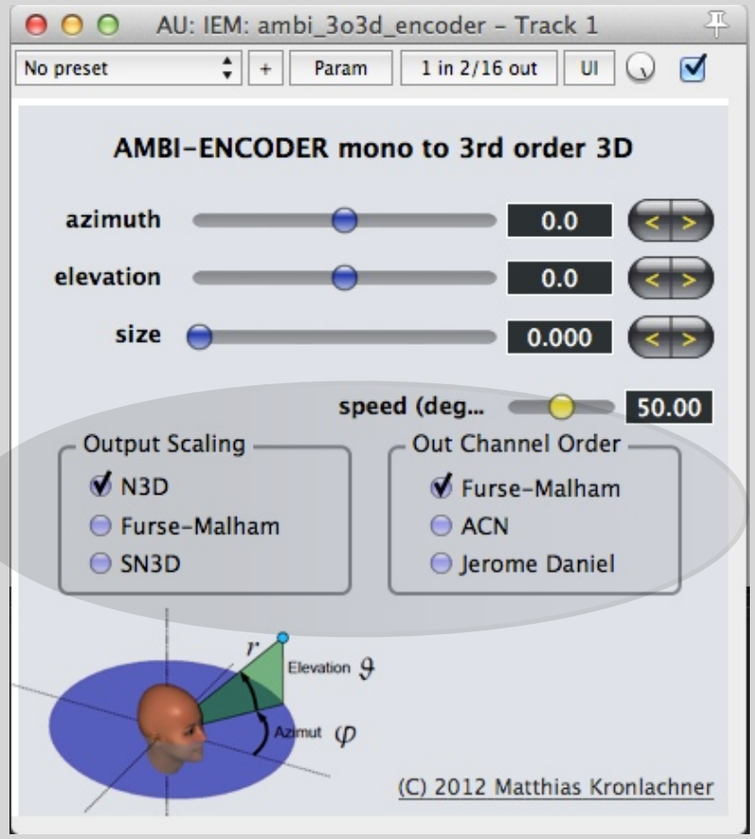
Ambisonics “standards”

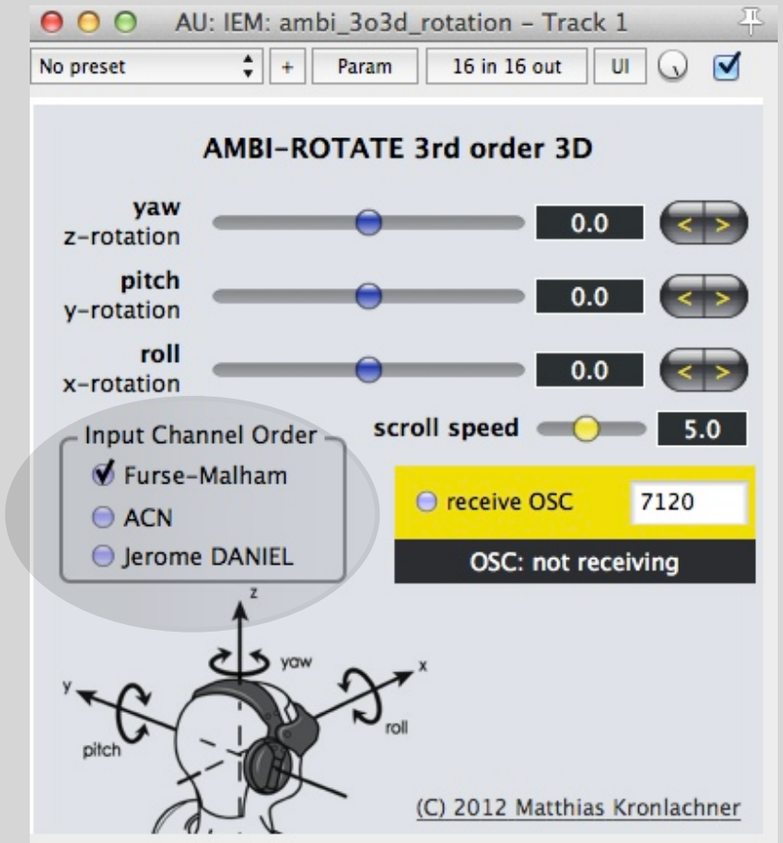
	sequence	***normalization***
ambix (I)	ACN	SN3D
Universal Ambisonics - .ua	SID	N3D
.amb (II)	FuMa	FuMa
iem_ambi Pd externals	SID	SN3D
...		

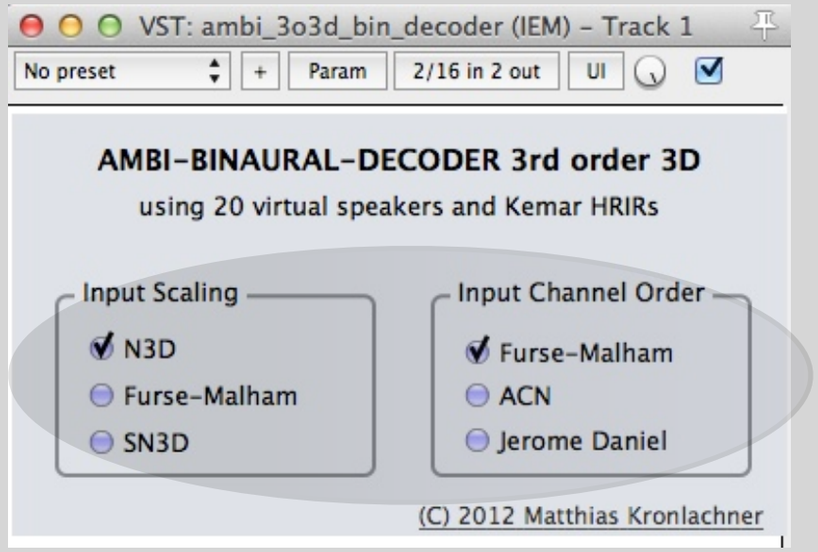
(I) Nachbar, Zotter, Deleflie, Sontacchi - AMBIX - A SUGGESTED AMBISONICS FORMAT AMBISONICS SYMPOSIUM 2011

(II) AMB plug-ins, Wigware, Ambisonics Studio plug-ins (Daniel Courville)

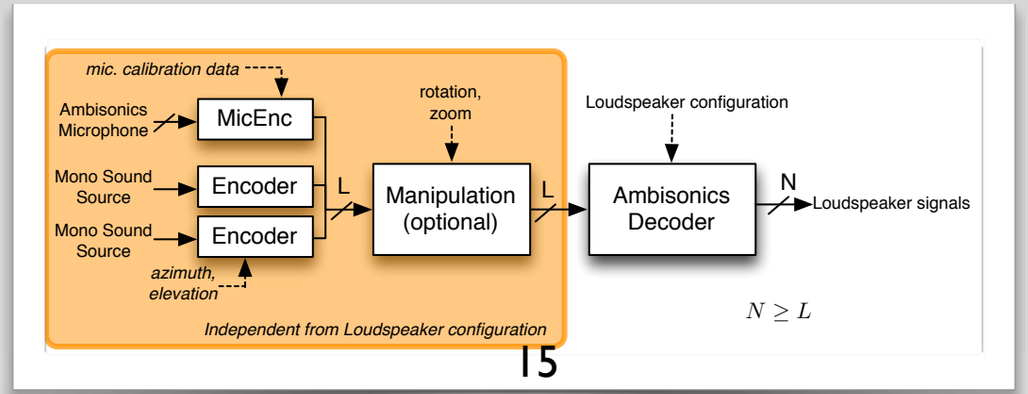
First approach...





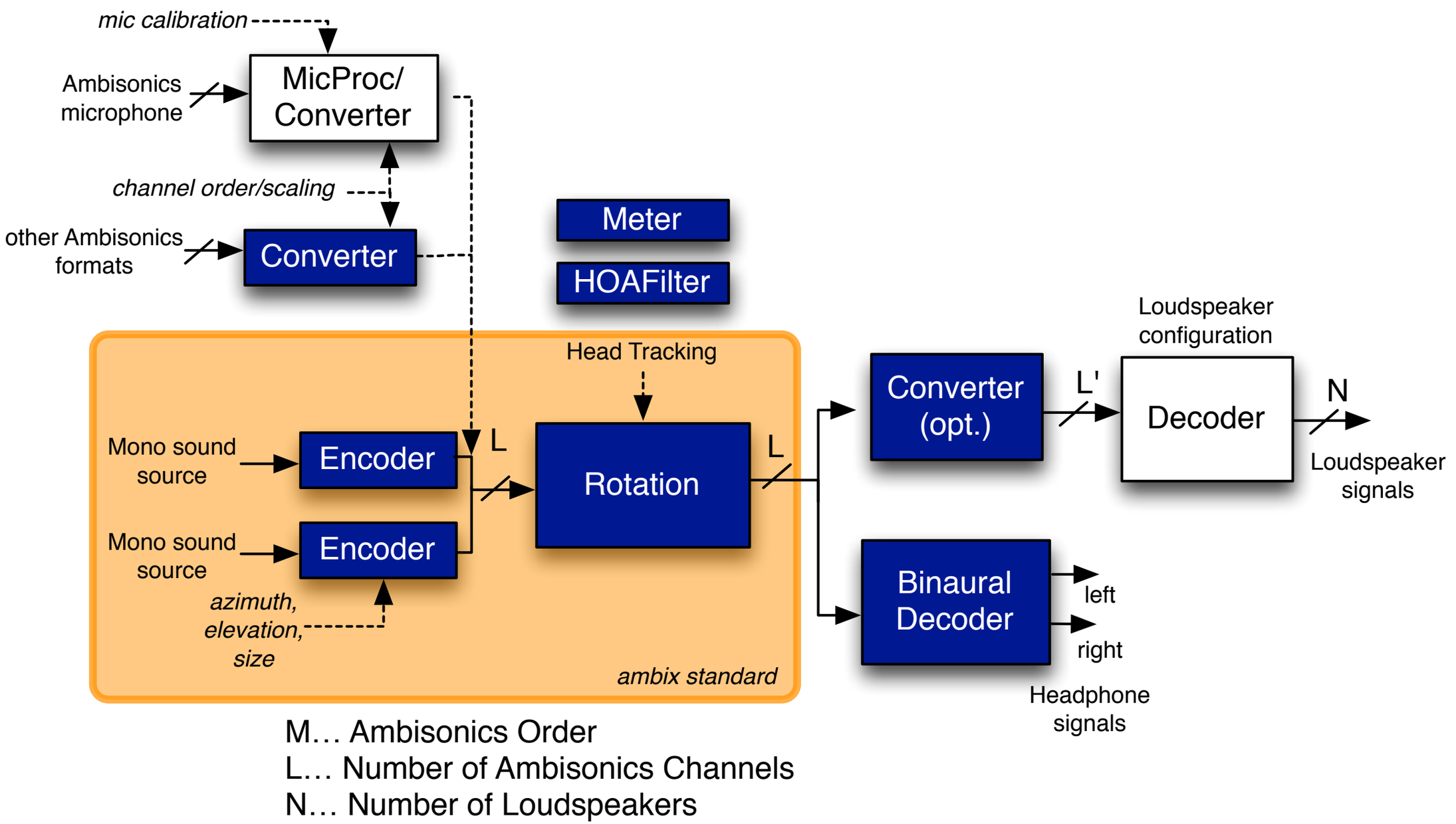


adjust scaling and channel order in every stage

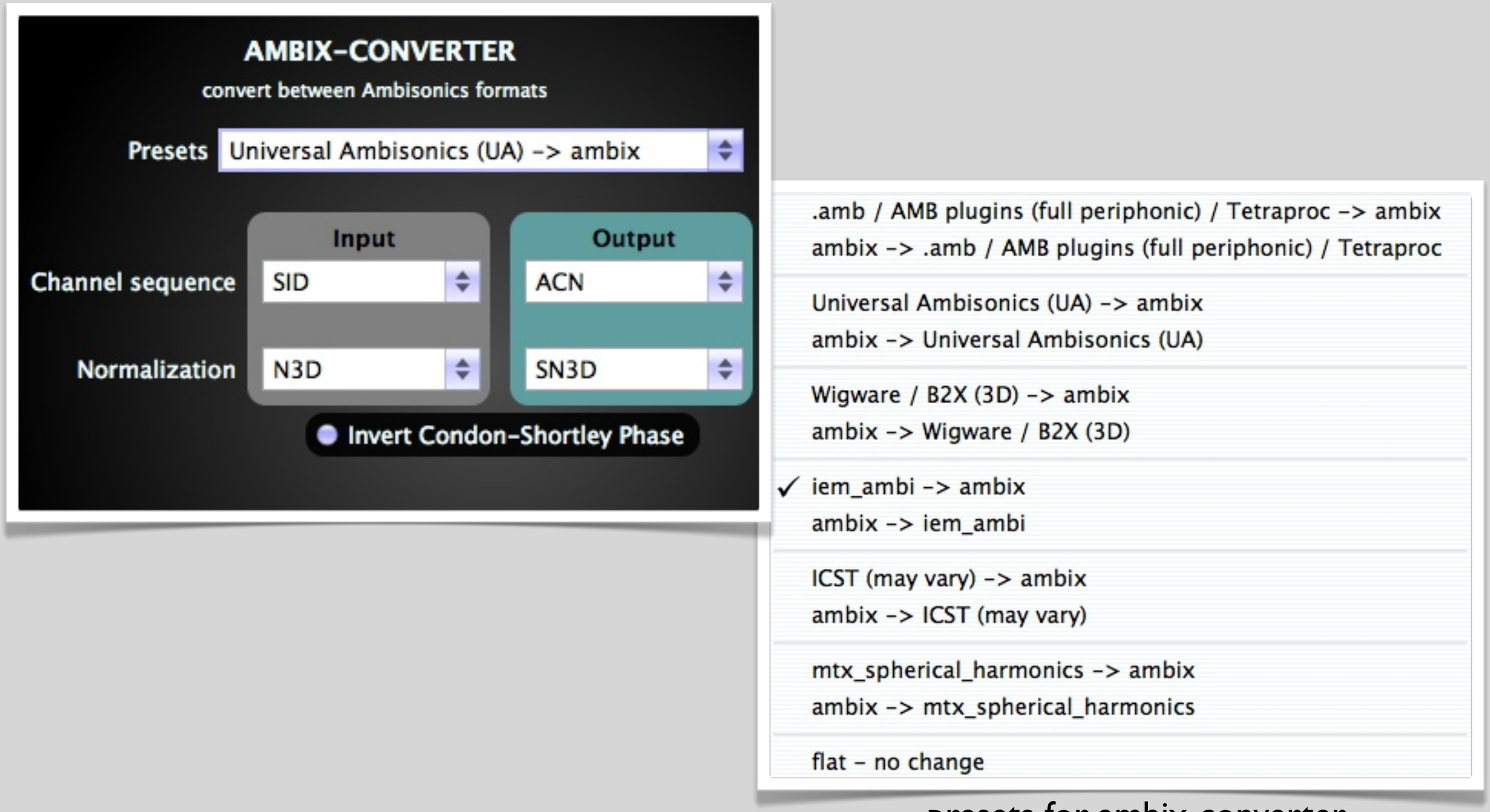


never released...

Ambisonics with ambix

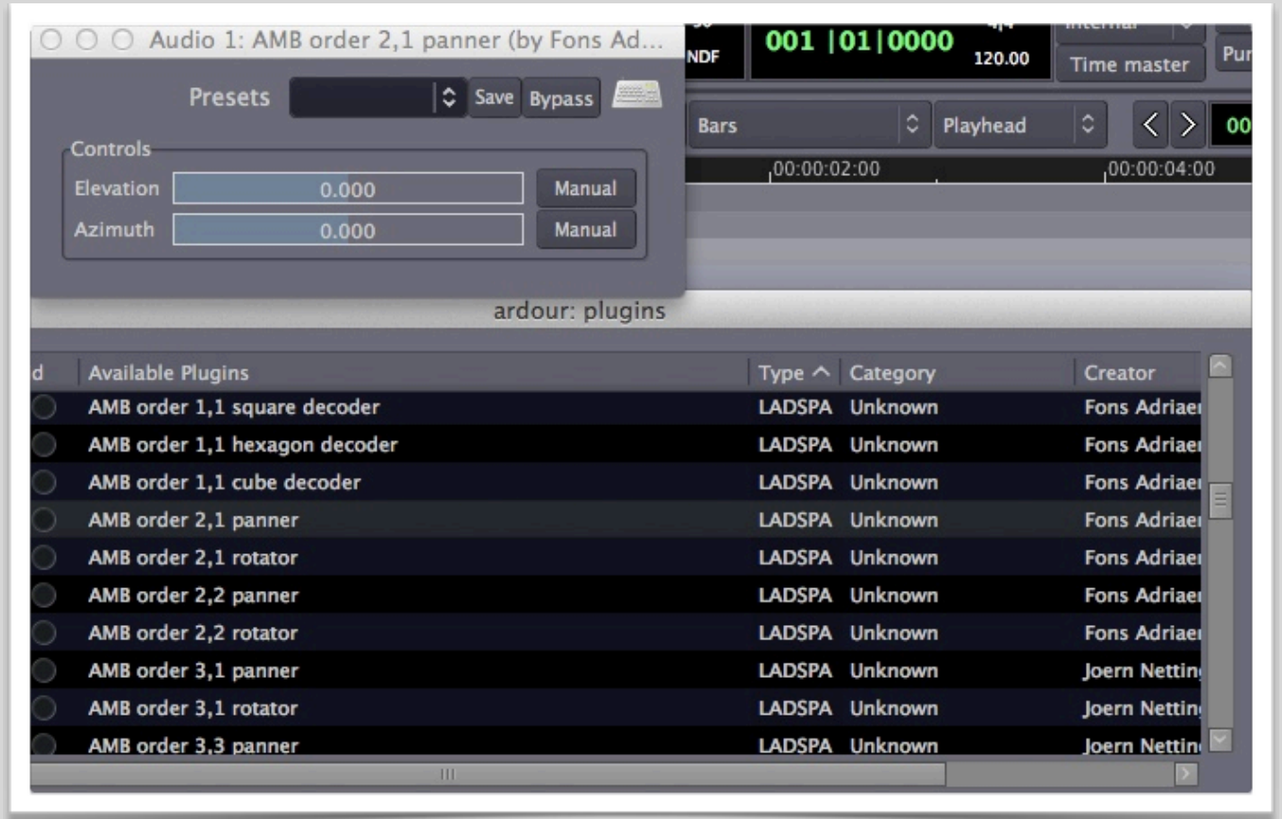


ambix-converter



presets for ambix-converter

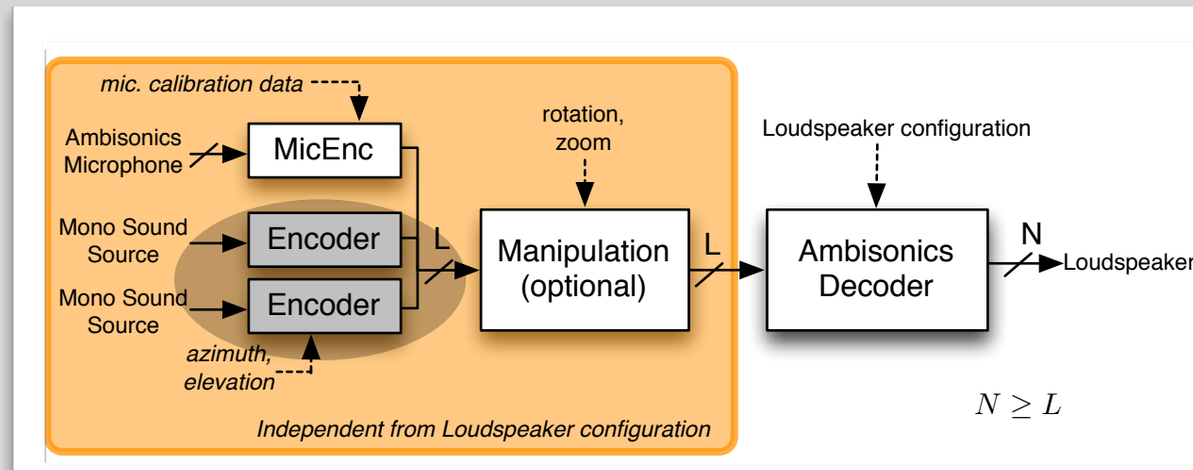
Encoders (panner)



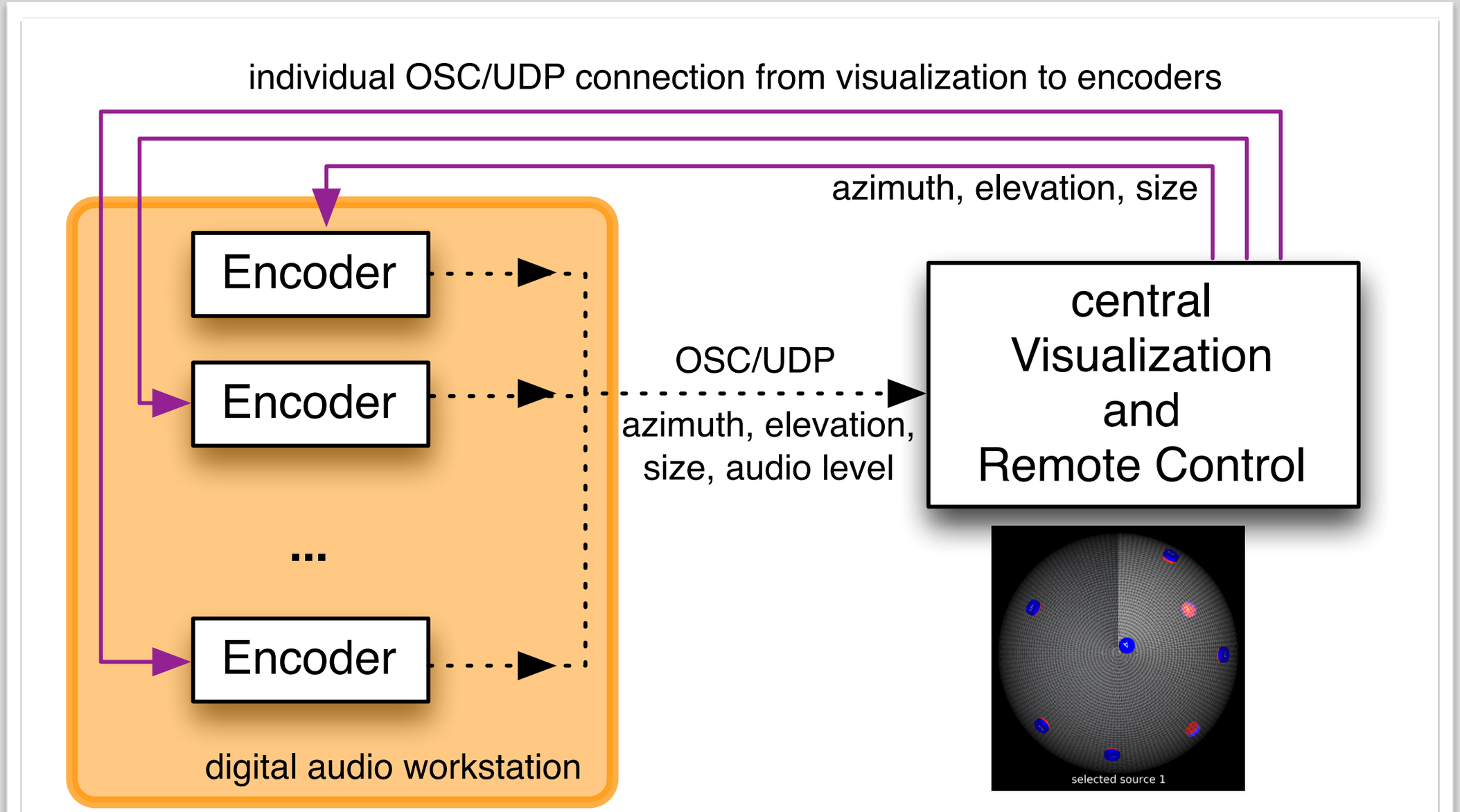
LADSPA AMB Plugins by Fons Adriaensen and Jörn Nettingsmeier

(Linux and MacOS - Ardour)

Daniel Courville's Ambisonics Suite (Mac OS)
2nd order 3D,
5th order 2D

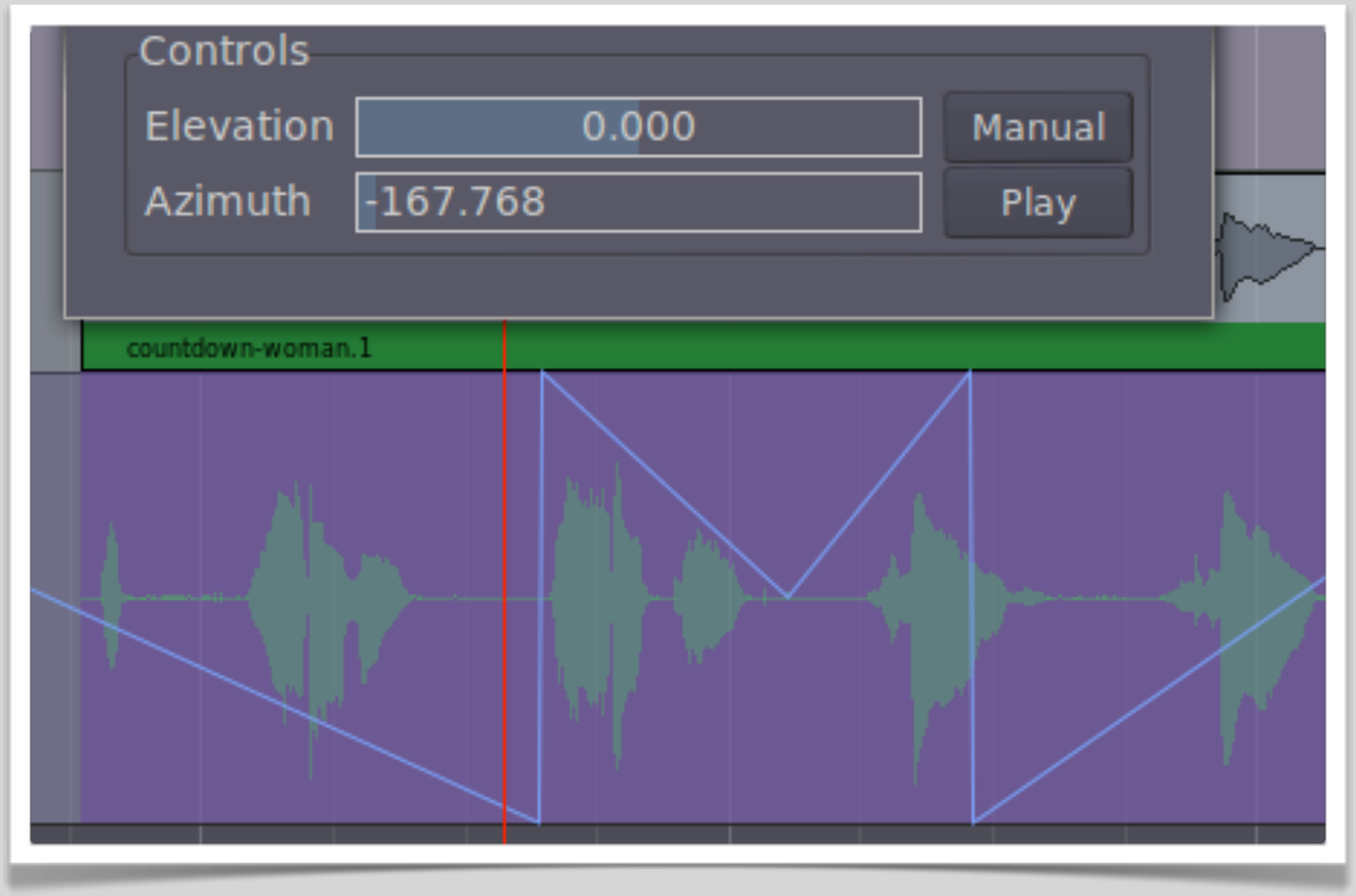


Remote control and visualization



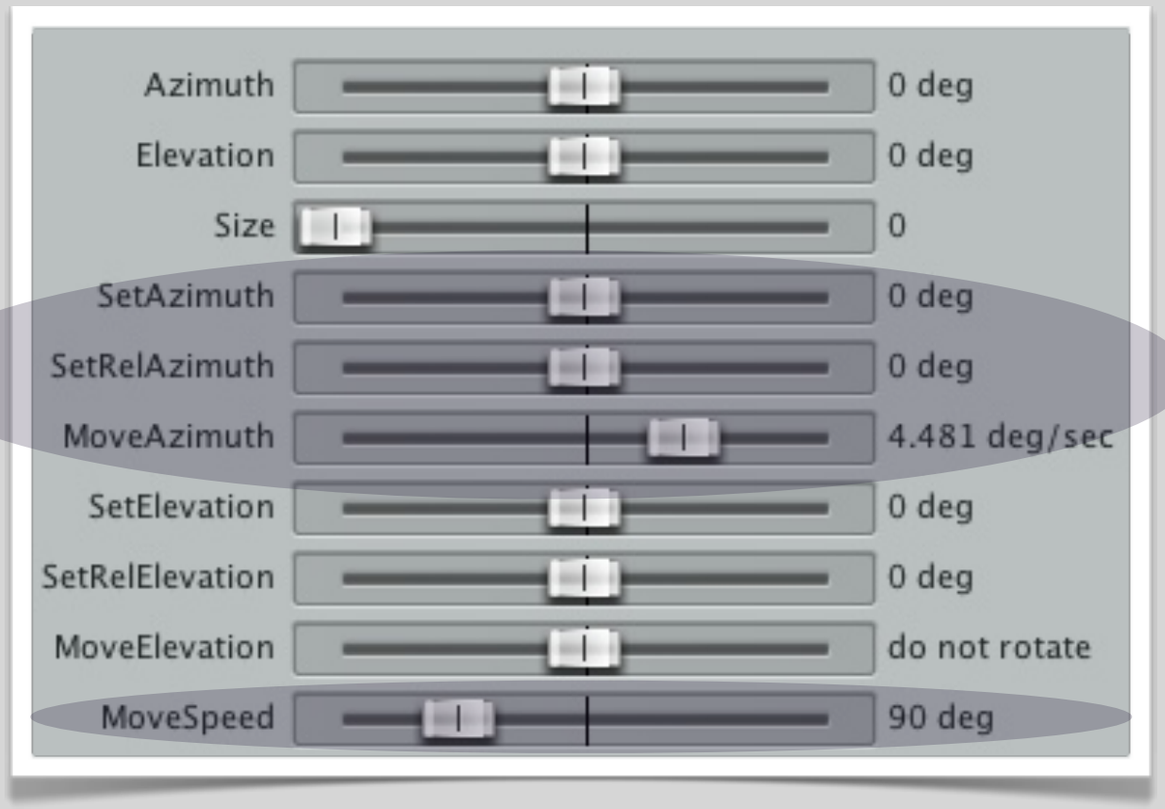
...example!

Jumping angular representation



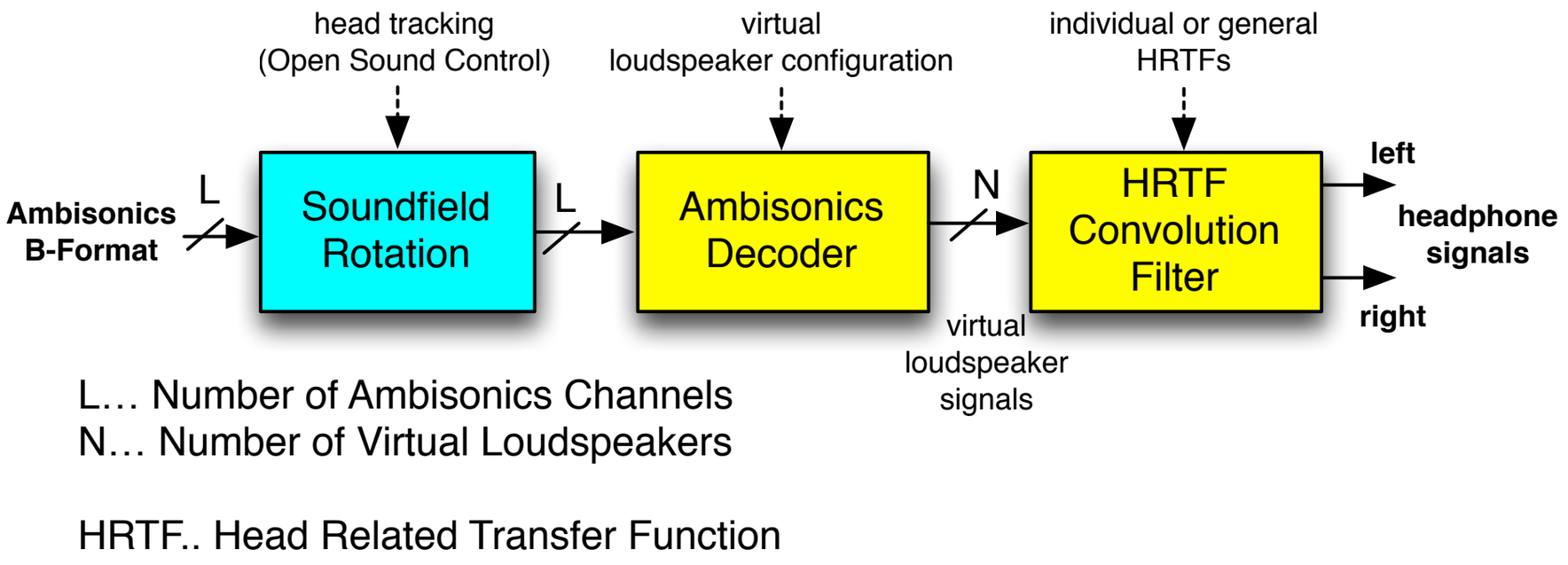
(visual) jump between
-180° and 180°

advanced control parameters



...example!

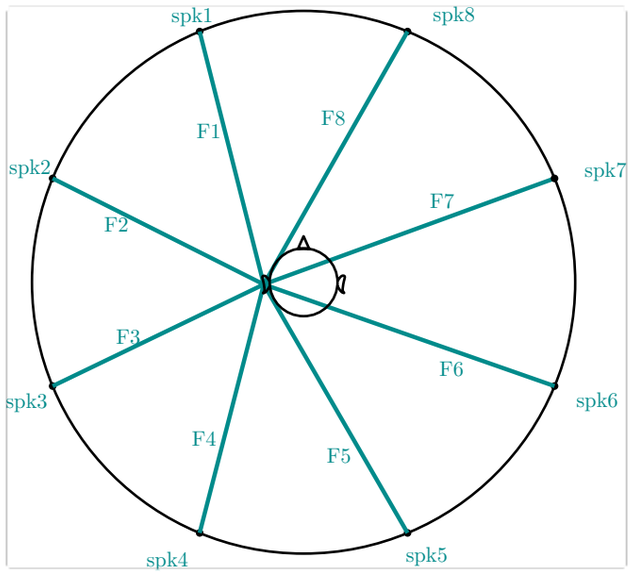
Listening at home



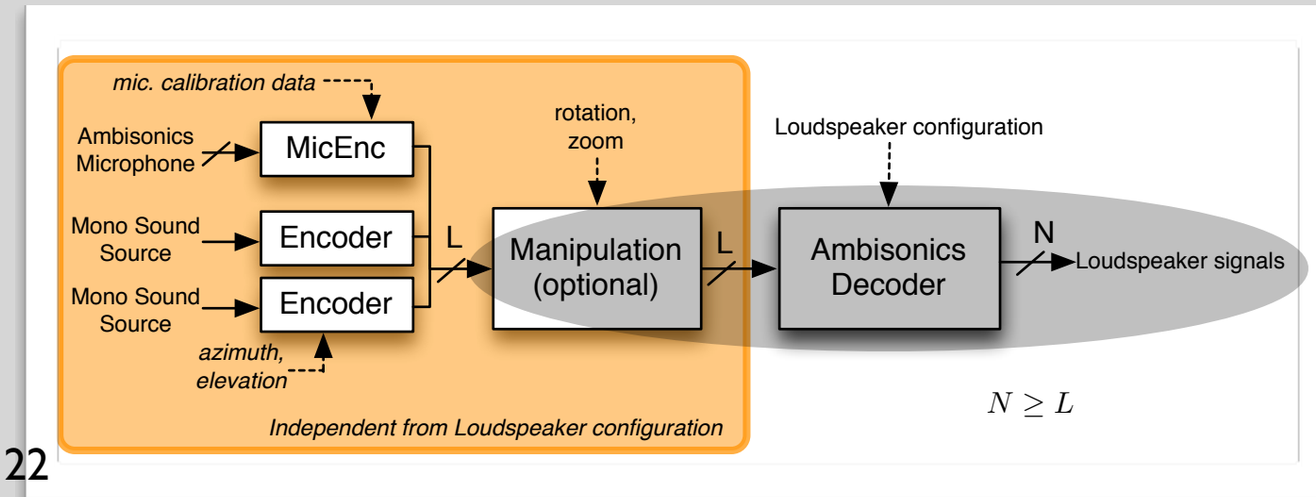
L… Number of Ambisonics Channels
N… Number of Virtual Loudspeakers

HRTF.. Head Related Transfer Function

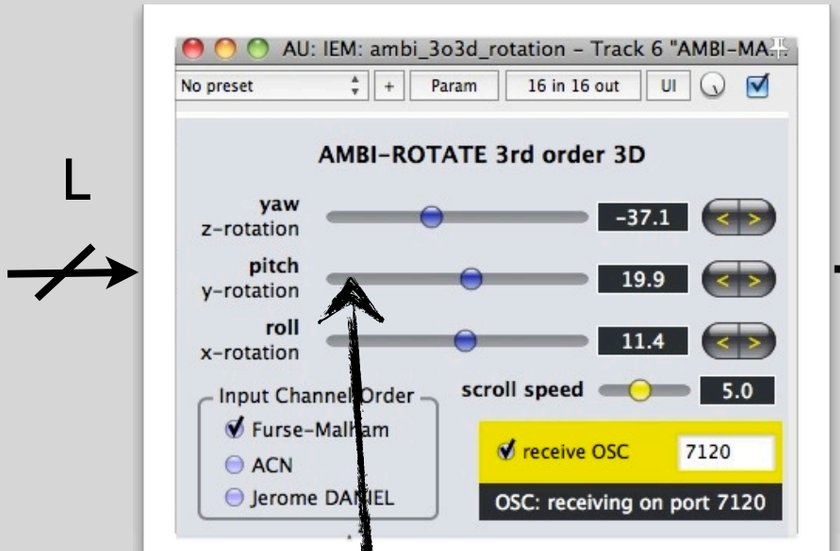
Ambisonics Binaural Decoder



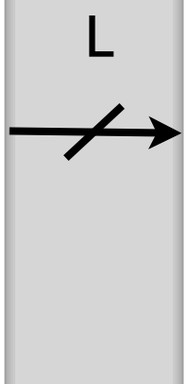
loudspeakers - left ear transfer path



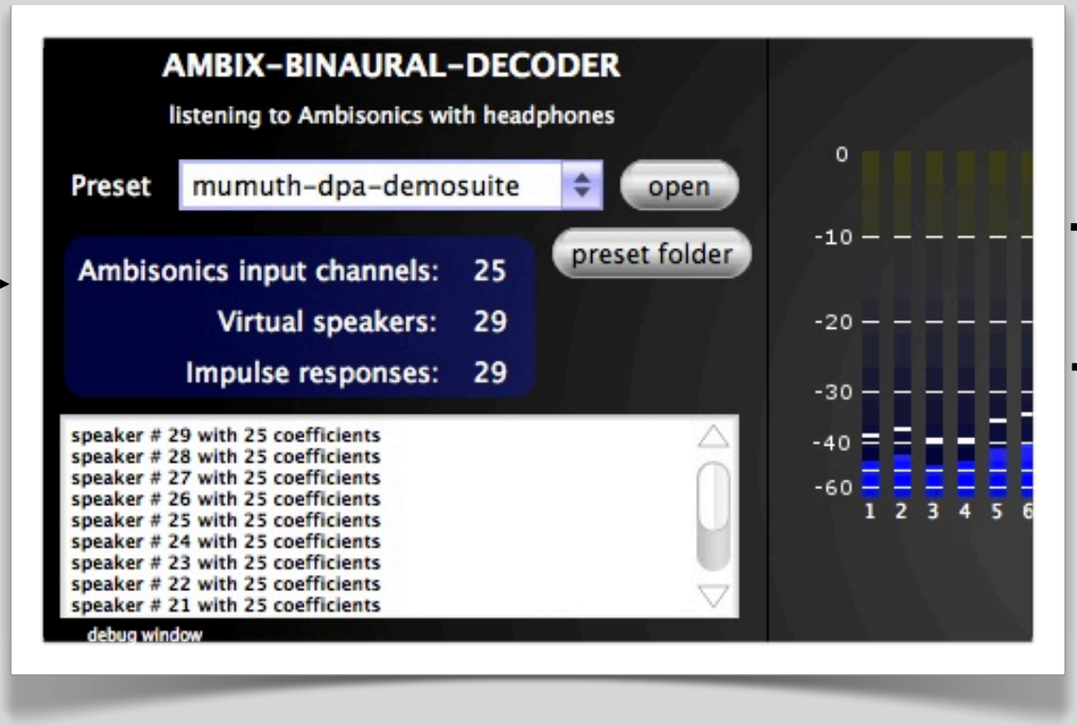
Binaural decoder



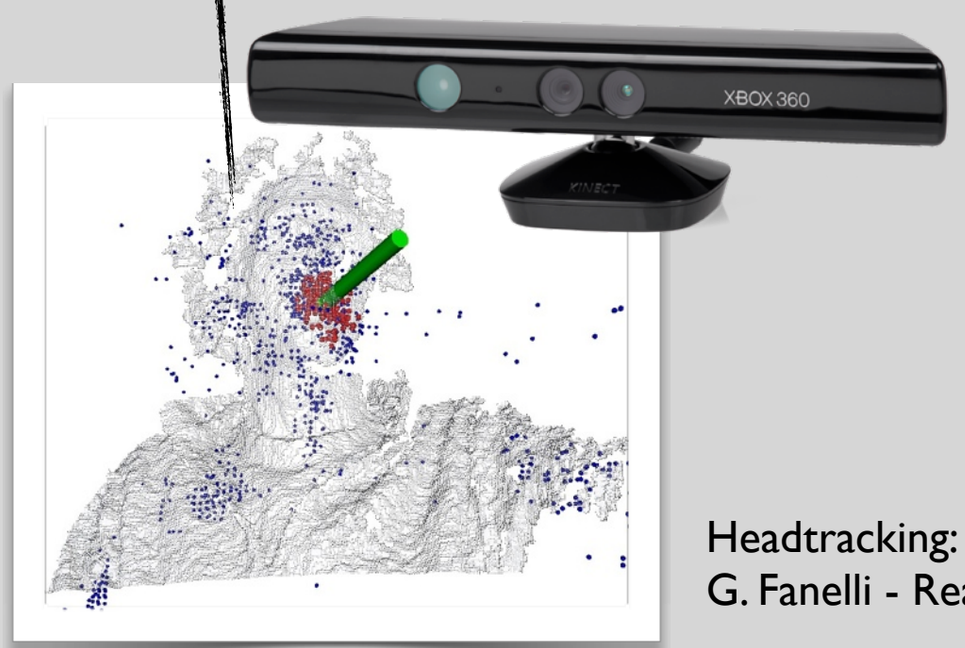
L



L



Stereo



using zita-convoler and zita-resampler

config files for impulse responses and decoder matrices

using identity matrix for directly driving the speakers

Headtracking:
G. Fanelli - Real Time Head Pose Estimation from Consumer Depth Cameras

Binaural decoder

Mumuth Graz, 29 Speakers in the hemisphere

Florian HOLLERWEGER and Martin RUMORI
Production and Application of Room Impulse Responses for Multichannel Setups using FLOSS Tools
LAC2013

Binaural decoder

IEM Cube Graz, 24 Speakers in the hemisphere

iem_cube_h1_mb_Deven1
iem_cube_h1_mb_Dhemi1
iem_cube_h1_mb_Dmusil
iem_cube_h1_mb_Dregul
iem_cube_h1_mb_Dvoronoi
iem_cube_h1_mb_ls_test

iem_cube_h2_mb_Deven1
iem_cube_h2_mb_Dhemi1
iem_cube_h2_mb_Dmusil
iem_cube_h2_mb_Dregul
iem_cube_h2_mb_Dvoronoi
iem_cube_h2_mb_ls_test
iem_cube_h2_mb_Quadro

itu5.1-lstest
itu5.1-ord1-optim
itu5.1-ord2-optim

mumuth-dpa-demosuite
mumuth-dpa-ls-test

mumuth-kk-demosuite
mumuth-kk-ls-test

octagon-3h0v
octagon-lstest

ring24-3h0v
ring24-lstest

square-lstest

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Things to do...

... for me (and maybe helpers?)

- fix bugs, especially with GUI
- easy (cross-platform) build system (DISTRHO?)
- ambisonics rotators (pitch, yaw, roll) above 3rd order

... for the community

- accept a standard concerning channel sequence and normalization above 3rd order (ambix?)
- DIY Higher Order Microphones

Questions?

Thank you!

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